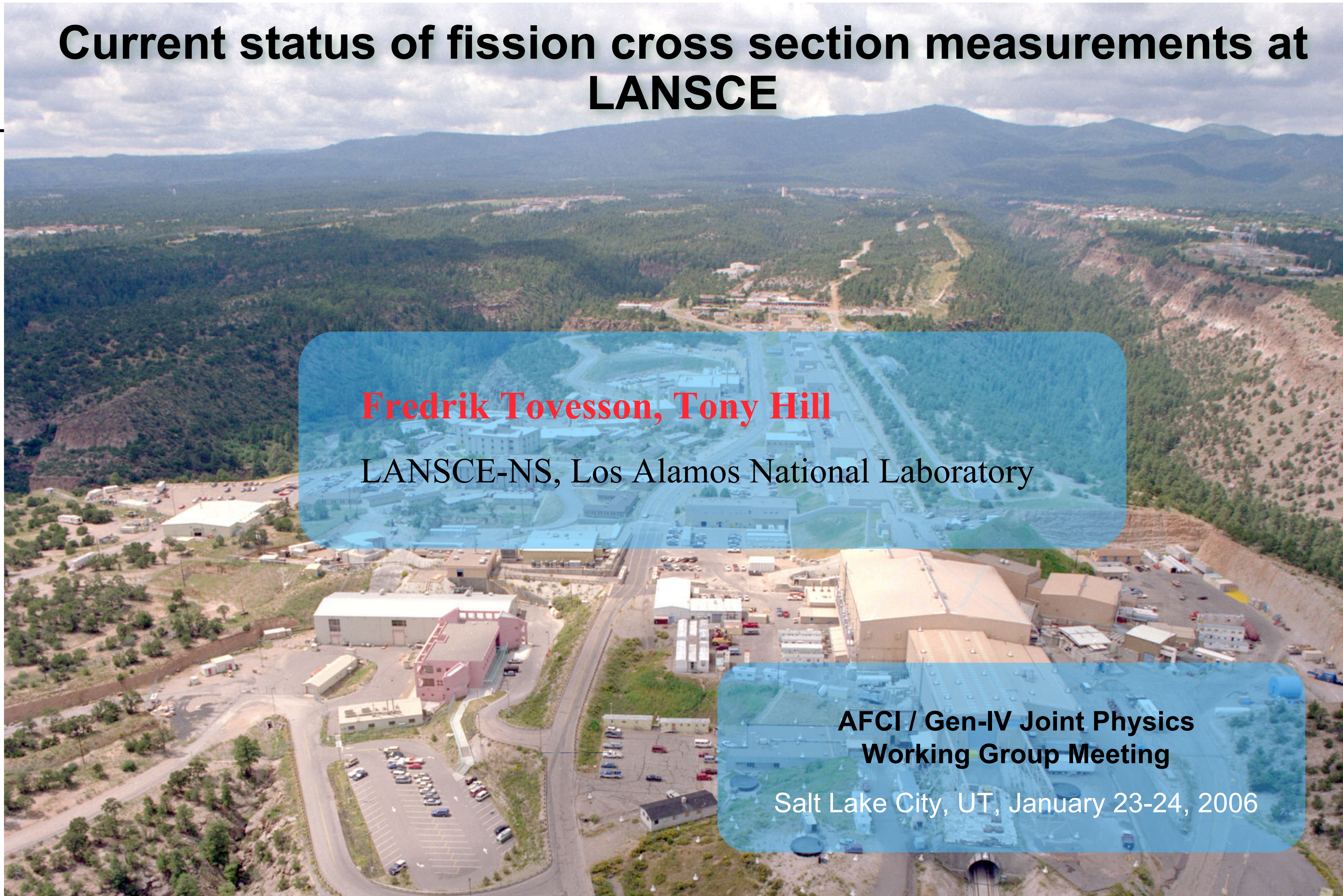
Current status of fission cross section measurements at LANSCE



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LANSCE-NS, Los Alamos National Laboratory

AFCI / Gen-IV Joint Physics Working Group Meeting

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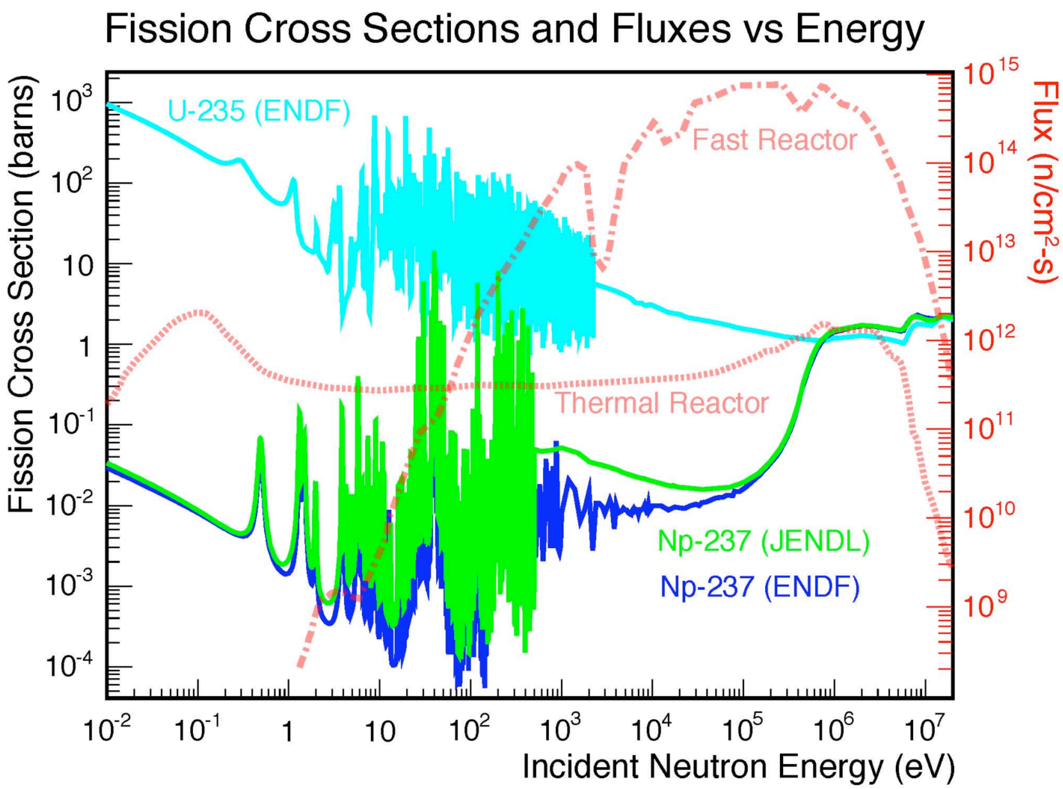
Outline

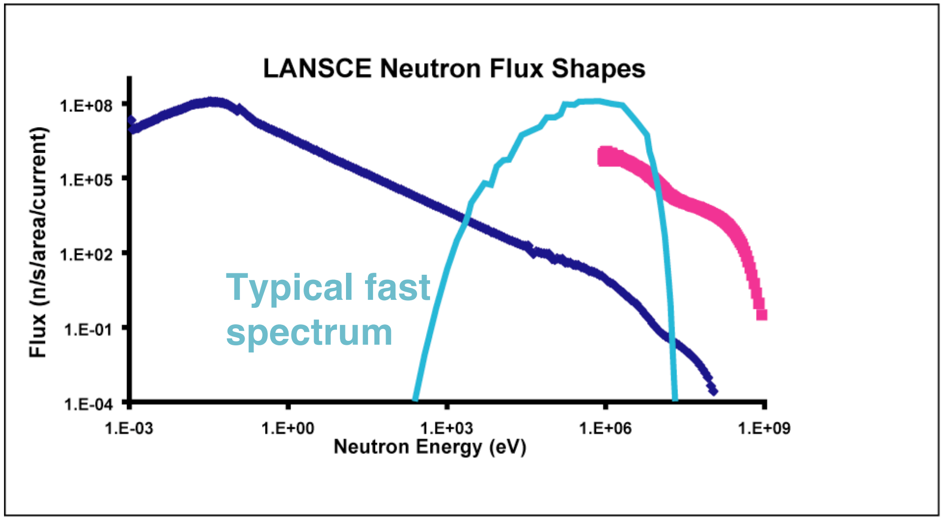
- The need for precision fission cross section measurements
- Facility and experimental setup
- Final result for $^{237}Np(n,f)$ from thermal to 200 MeV
- Preliminary results for $^{242}Pu(n,f)$ (sub-threshold)
- Preliminary data for $^{240}Pu(n,f)$

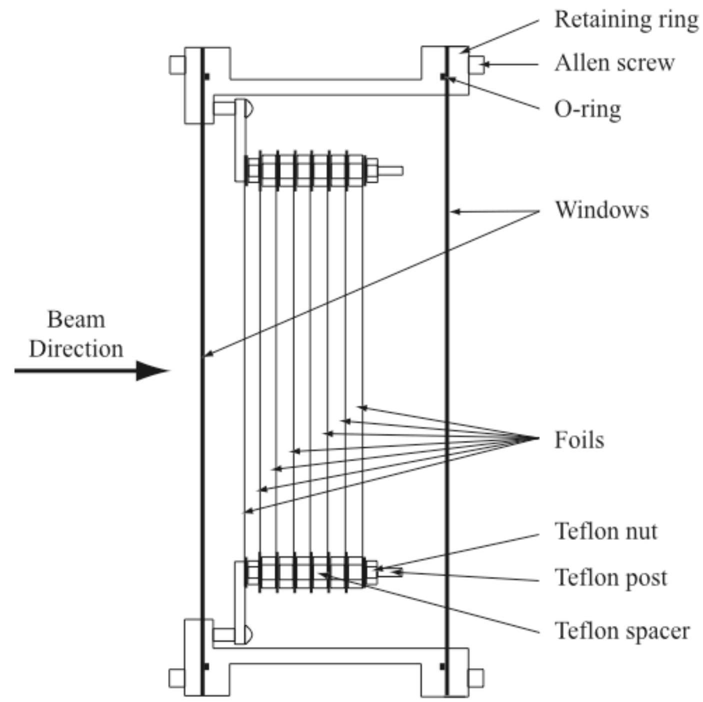
AFCI funds cross section measurements to reduce uncertainties in transmutation and Gen-IV reactor designs



- Future nuclear reactor will probably have fast neutron spectrum
- This allows for efficient transmutation of actinides such as ^{237}Np
- There is a need for improving cross section data (fission and capture) in the fast region
- The LANSCE spallation neutron source is ideal for these measurements

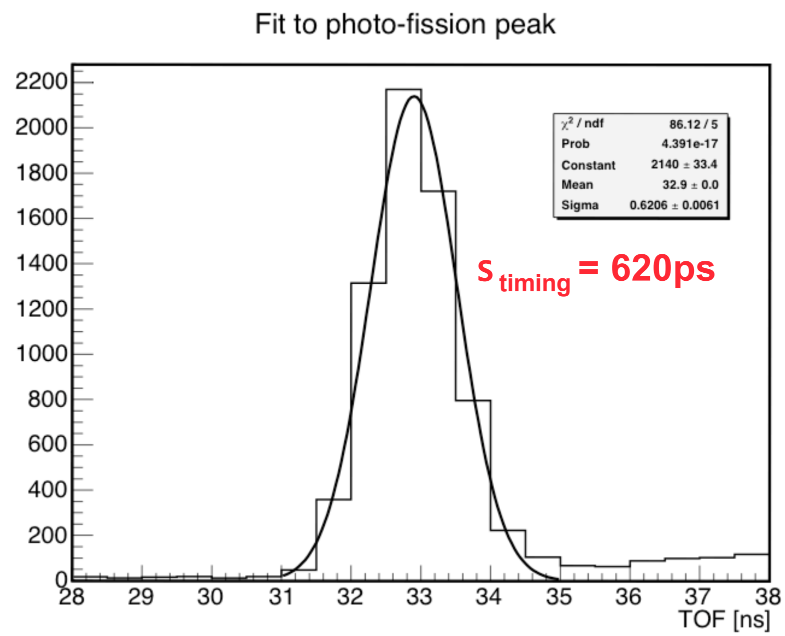
The experiment



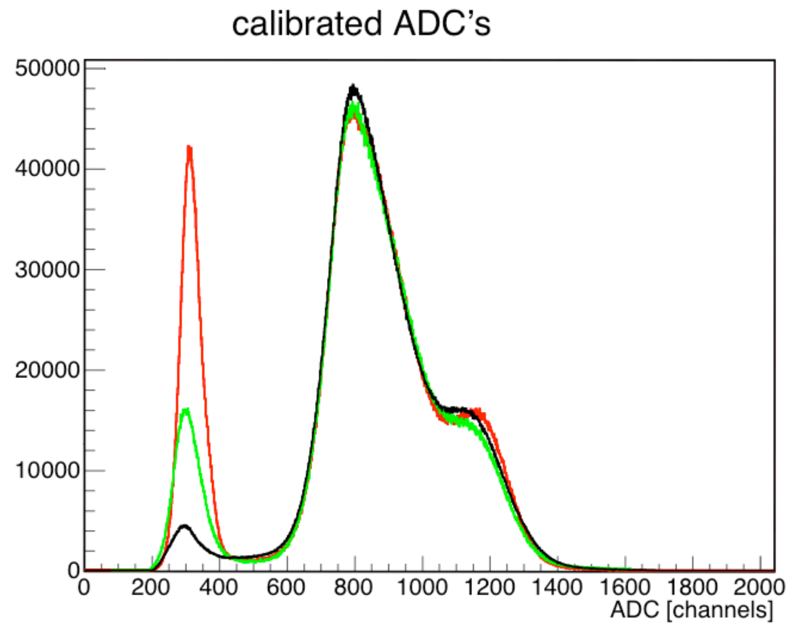


- Two facilities used to cover full energy range: LUJAN (10^{-2} eV – 200 keV) and WNR (100 keV – 200 MeV)
- Fission detector: multiple target parallel plate ionization chamber.
- For each event the energy deposition and relative timing was recorded.
- The ^{237}Np fission events were measured simultaneously with ^{235}U (n,f), which is a standard up to 20 MeV.

Detector response



TOF resolution for ^{235}U.



The ADC response for ^{235}U (black), ^{238}U (green) and ^{237}Np (red).

$\sigma_{protons} = 150ps$

$\sigma_{TDC} = 500ps$

$\sigma_{rest} = 330ps$

Data analysis

- **WNR (higher energy range):**
  - **Dark Current:** The proton accelerator delivers a low background current between beam pulses
  - **Wrap around:** Fissile targets (U^{235}) have TOF distributions that are longer than the proton pulse spacing
  - **Alphas:** from decay and (n, a) reactions

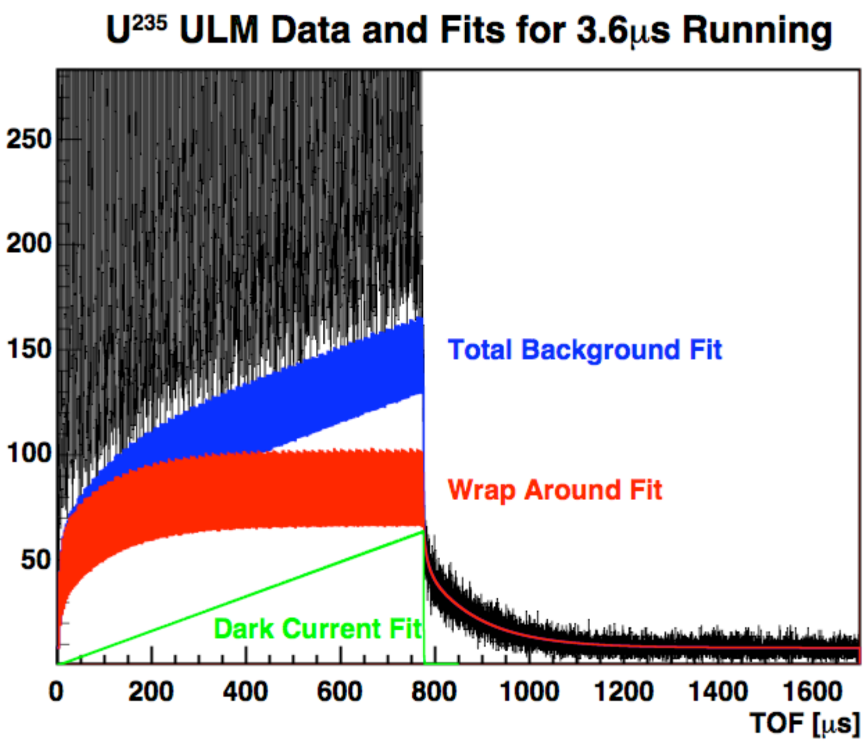
- **LUJAN (lower energy range):**
  - **Dead time:** Higher count rates than at WNR (3000 s^{-1} vs. 30 s^{-1}). Energy dependence needs to be taken into account
  - **Room scatter:** Neutron background caused by scattering in collimation and room
  - **Contamination:** Fissile contaminants have strong impacts in some energy regions

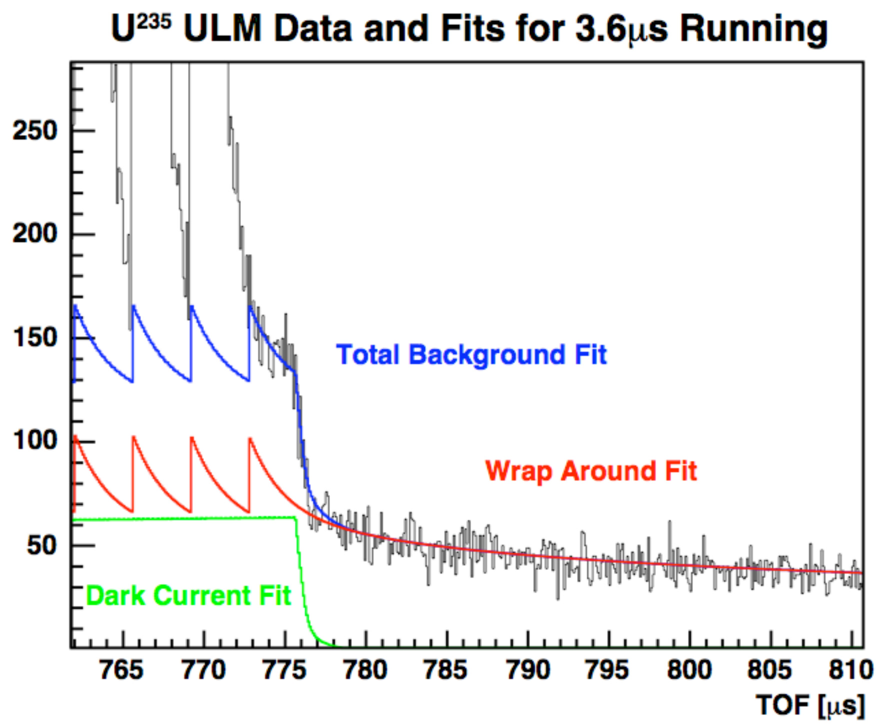
WNR (high energy) Background corrections

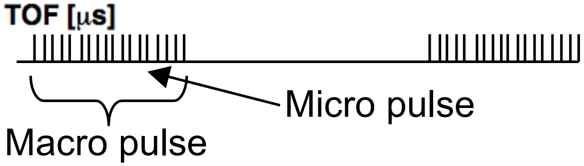
Three exponentials and a P_0 are used to parameterize the wrap around shape in the ULM data at end of the macro-pulse and includes contributions from all the T0's :

$$y(E) = P_0 + \sum_{i=0}^{nT0-1}\left[C_1 e^{(-a_1(E - i^* mps))} + C_2 e^{(-a_2(E - i^* mps))} + C_3 e^{(-a_3(E - i^* mps))}\right],$$

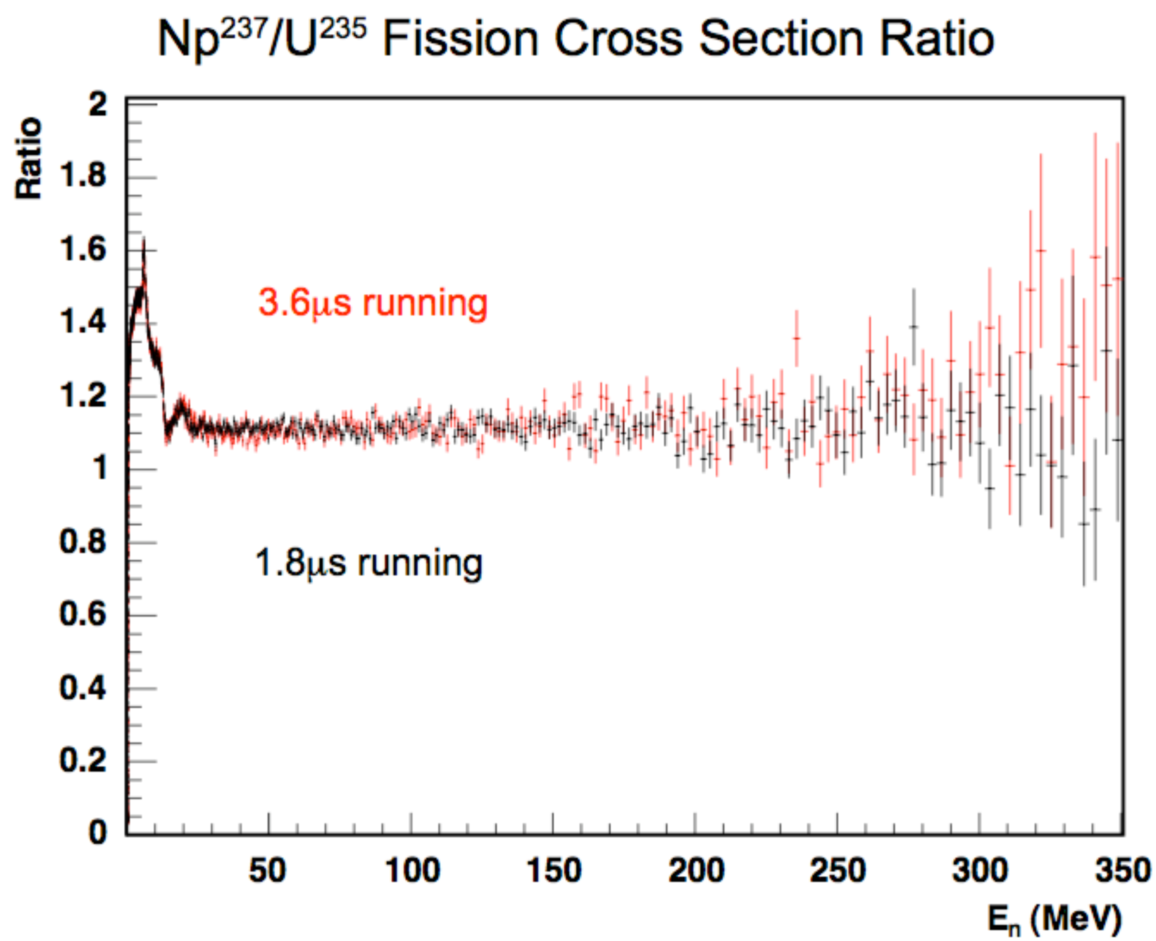
where mps is the micro-pulse spacing and E is the incident neutron energy. $P_0, C_1, a_1, C_2, a_2, C_3$ & a_3 are allowed to float in a fit to the ULM data between macro-pulses.







The 1.8μs and 3.6μs mps fission ratios are consistent



Data was collected with two different micro-pulse spacing. The wrap-around and dark current corrections are very different in the two cases.

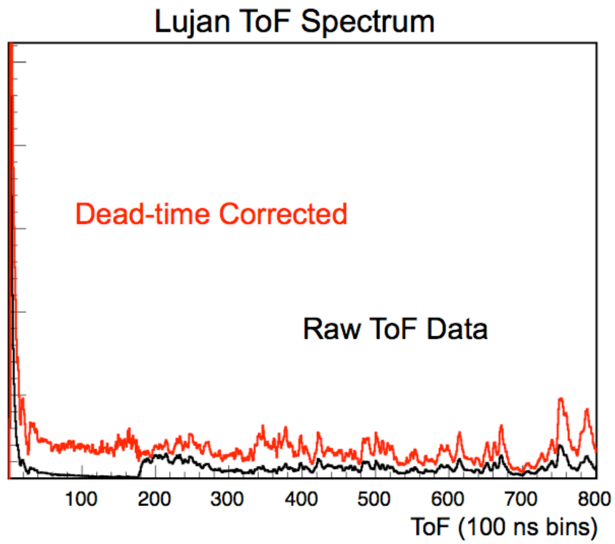
Comparison of data sets (200 kEV to 350 MeV):

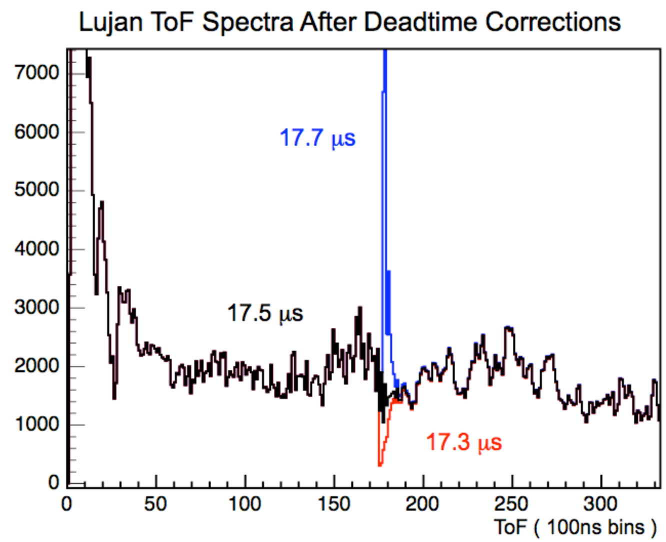
$\chi^2_{reduced}$ **= 0.9877**

P = 58%

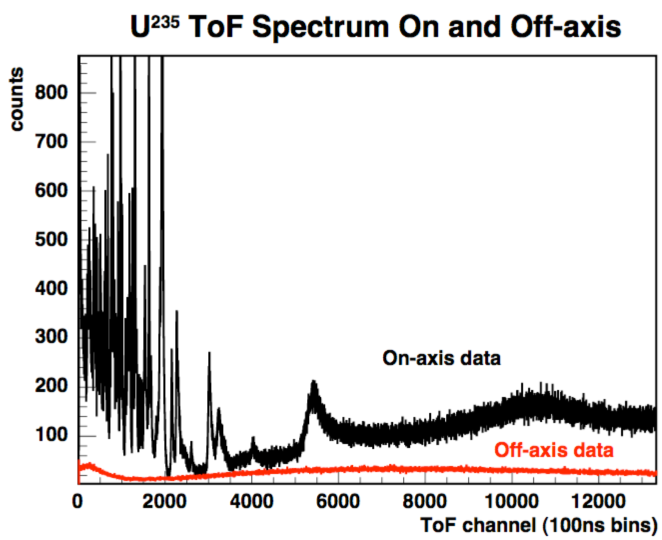
Data from different running conditions will be combined for final result

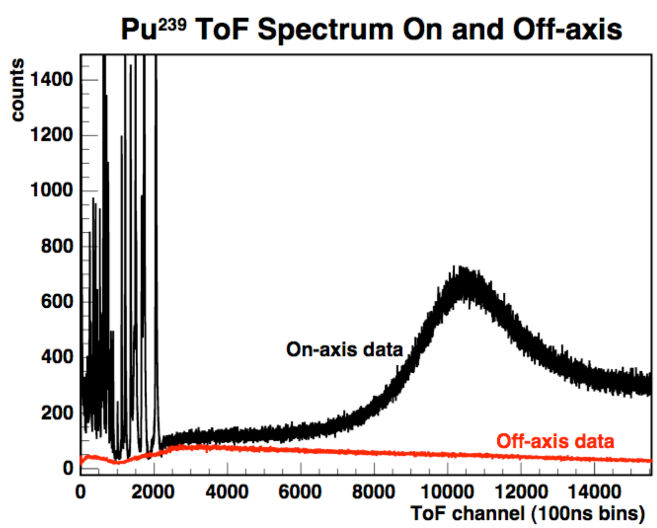
LUJAN (lower energy) Background correction





Foil	Measured live-time	Calculated live-time
U^{235}	81.9%	81.1%
Pu^{239}	62.5%	63.5%
U^{233}	81.5%	82%

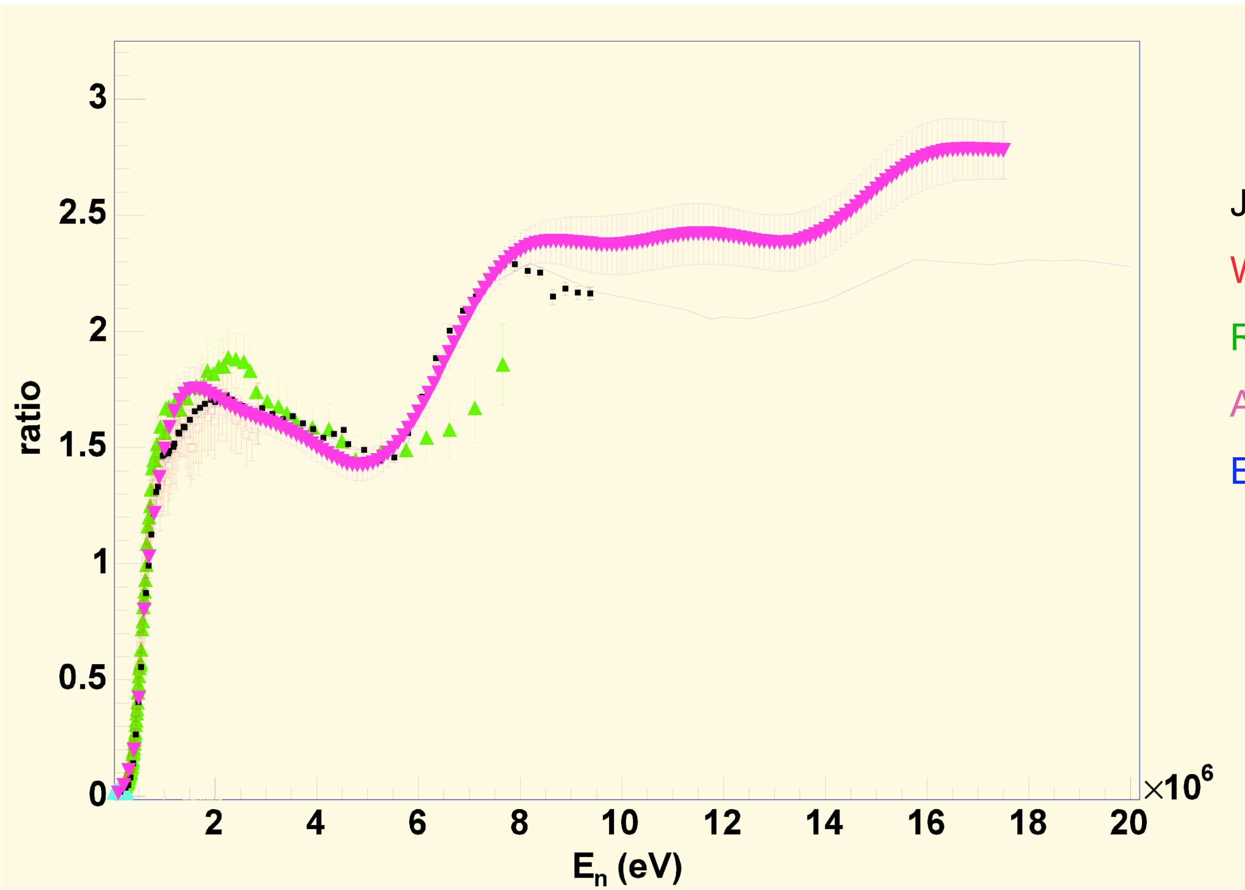




- Algorithm used for energy dependant dead time correction (Bowman / Coats). Results compared to measured live-time

- Out-of-beam measured used to subtract off room-scattered background

Available fission data for ^{237}Np



J. W. Meadows et al., 1983

W. K. Brow et al., 1970

R. J Jiacoletti et al., 1972

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ENDF/B-VI

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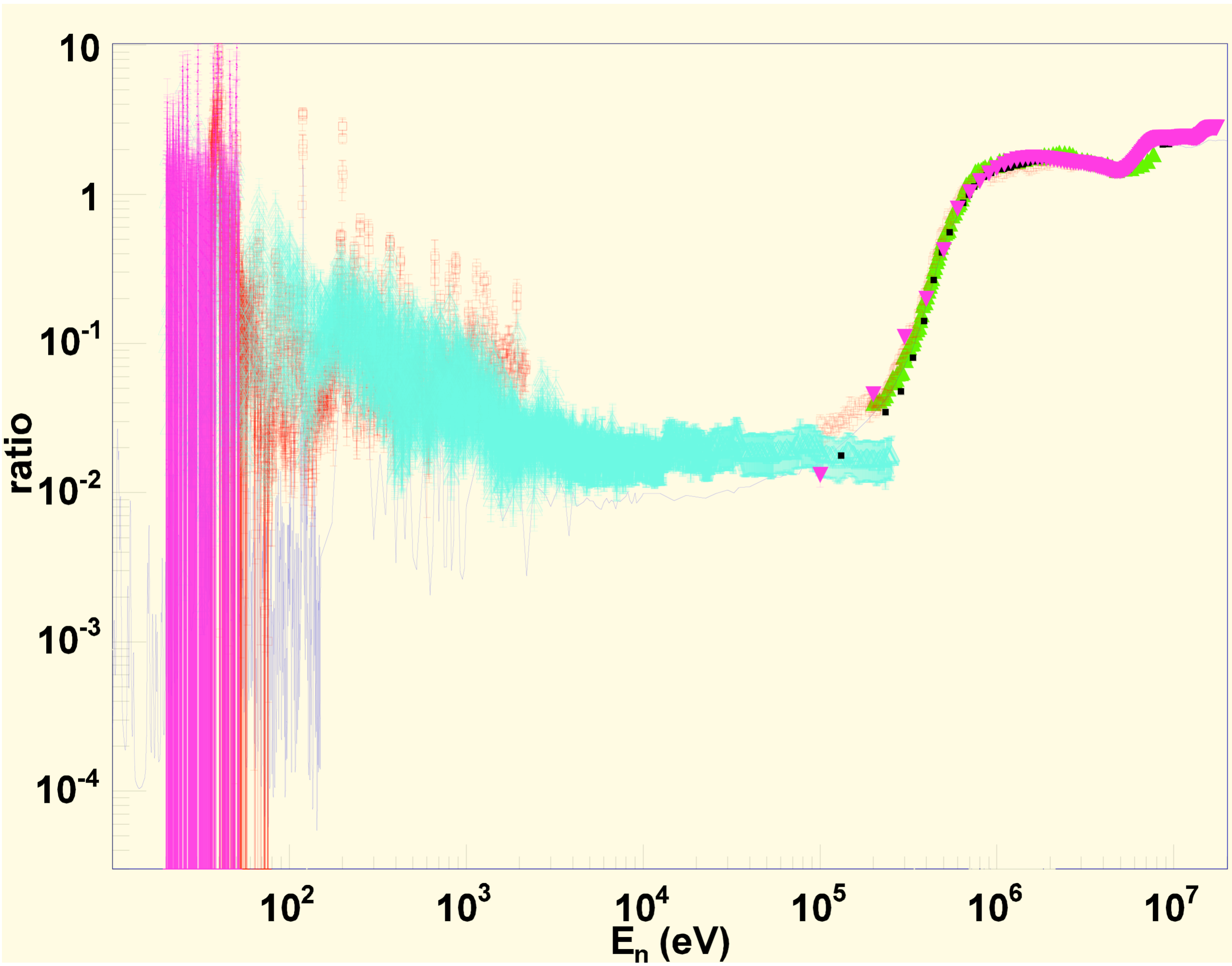

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A. A. Lapenas et al., 1975

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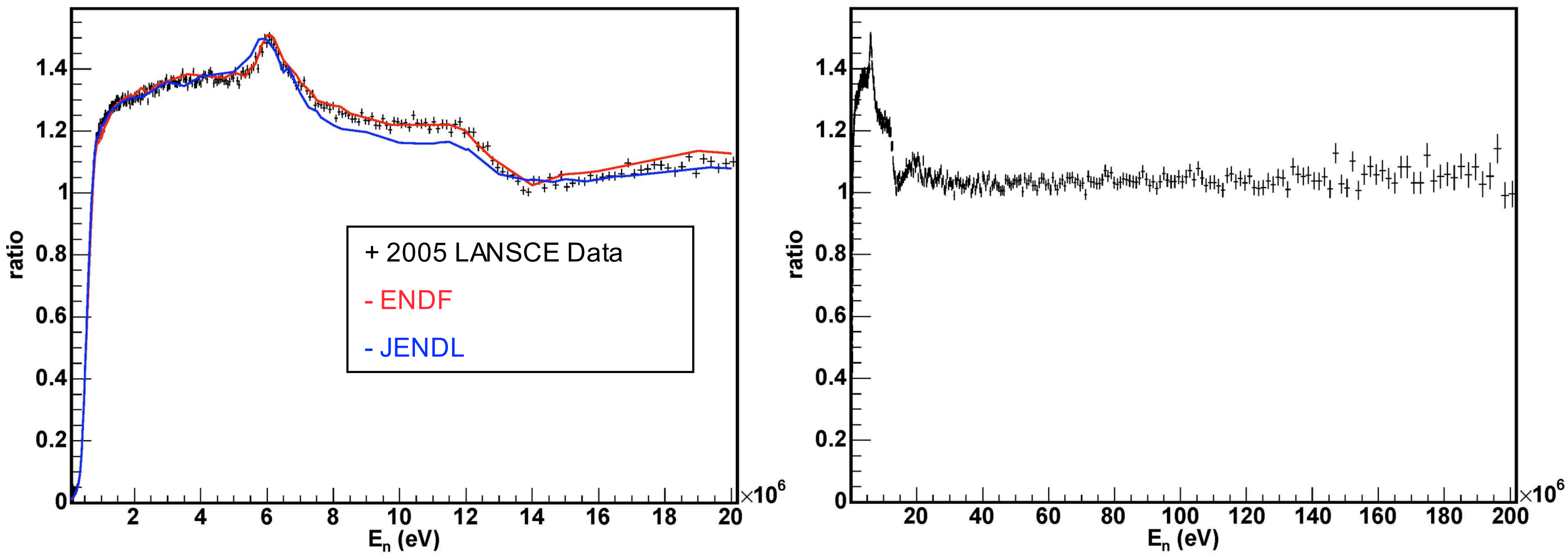
ENDF/B-VI

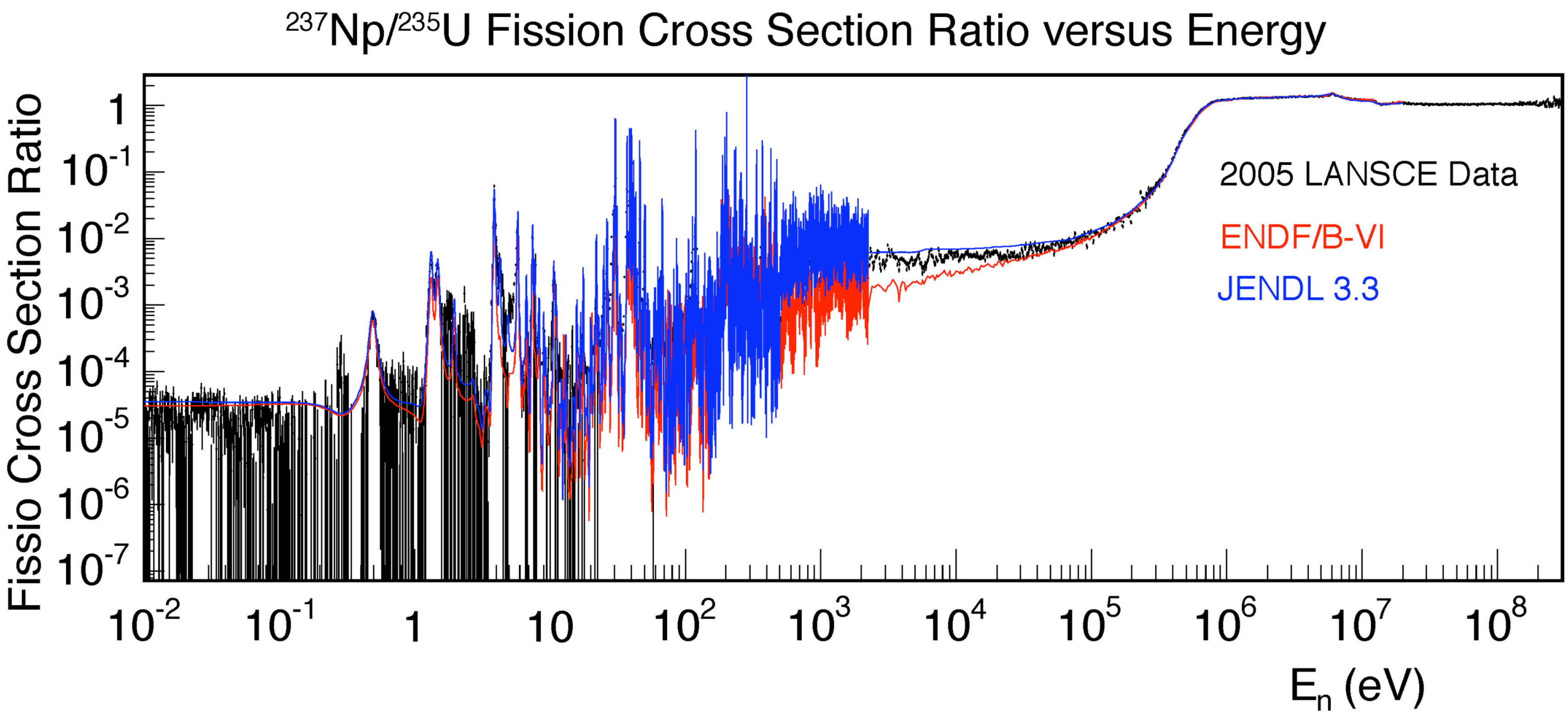
Results for ^{237}Np

^{237}Np(n,f) / ^{235}U(n,f) cross section ratio

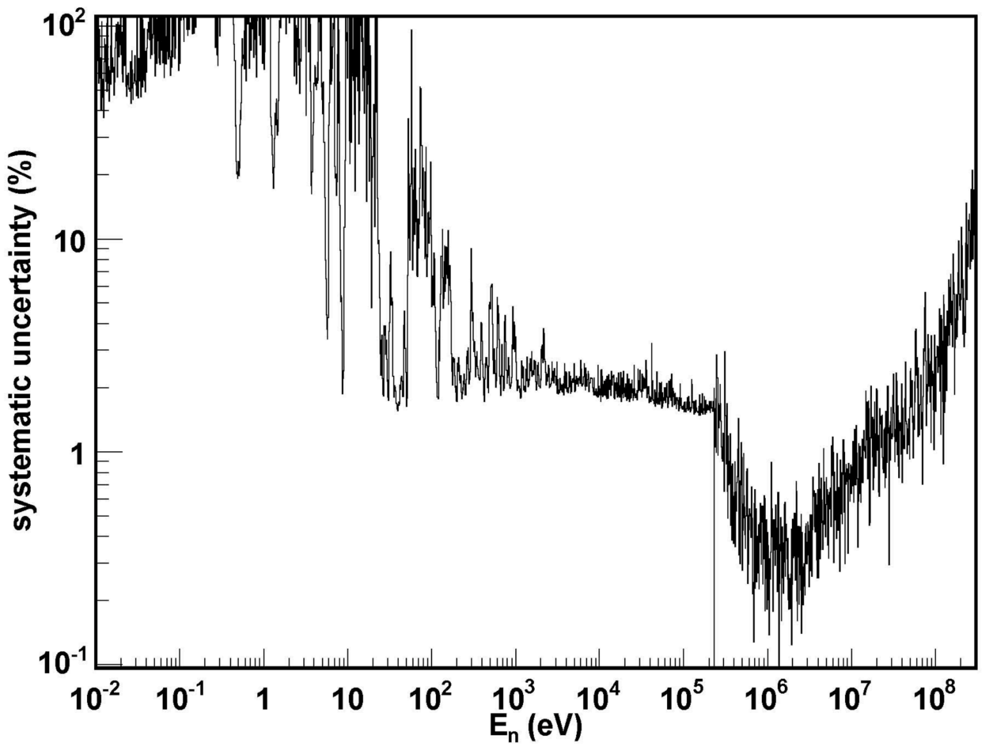


- Data show best agreement with the ENDF evaluation above ~4 MeV
- The ^{237}Np / ^{235}U ratio is flat above ~50 MeV

Results for ^{237}Np



Systematic uncertainties

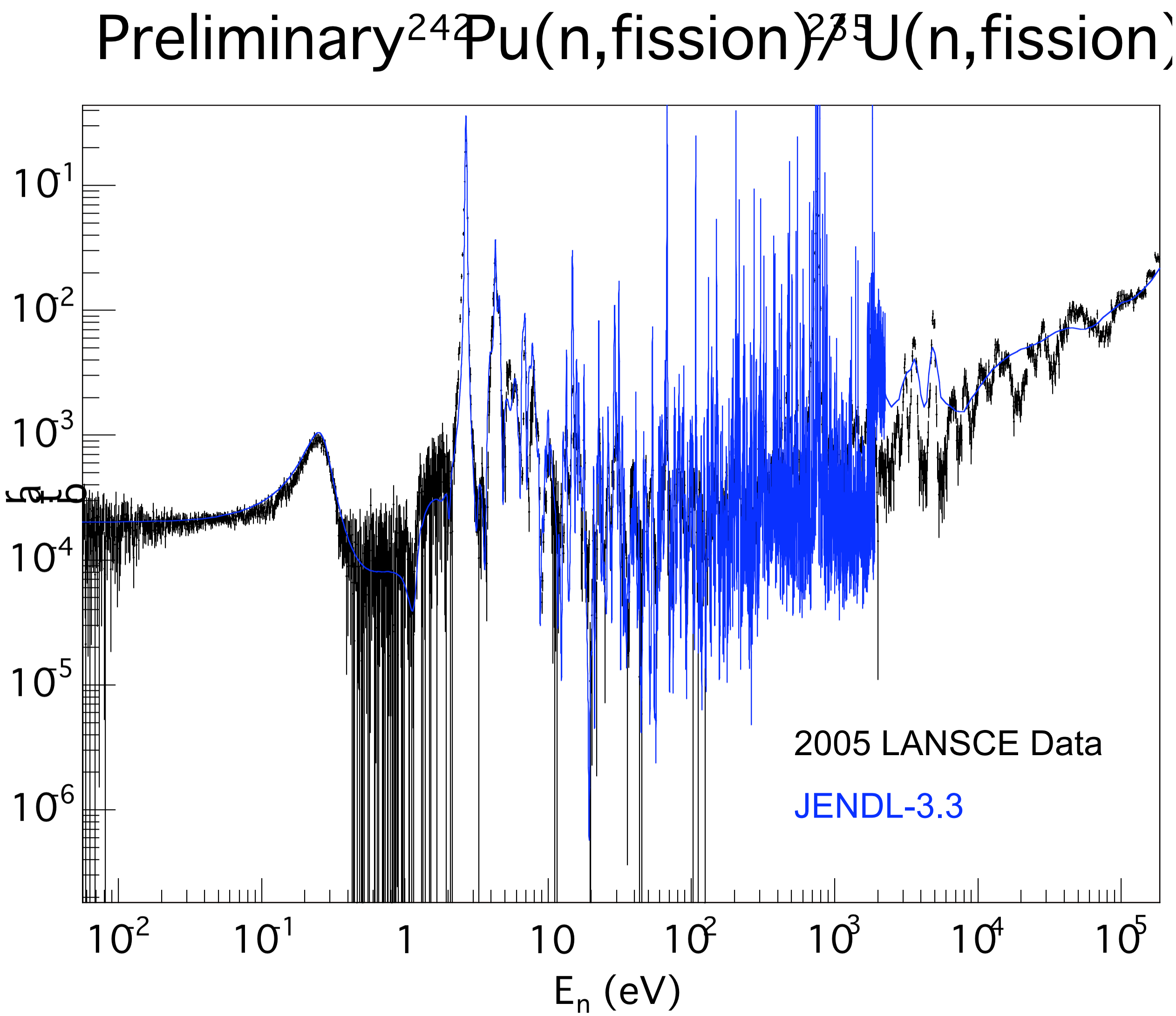


Sources of systematic errors:

- Dead-time correction
- ADC bias
- Contamination correction
- Cave background correction
- Wrap-around
- Dark current

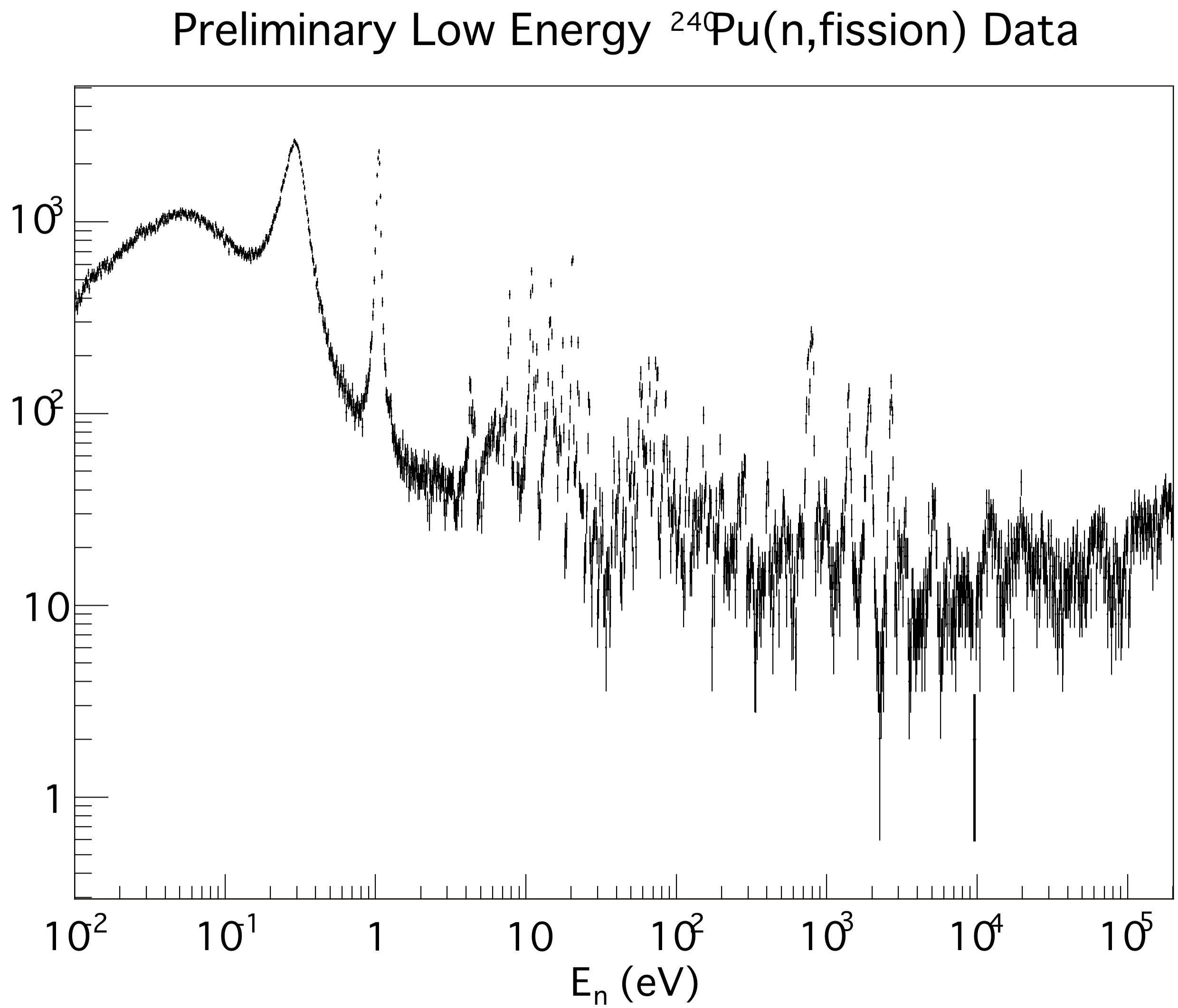
Uncertainty of the normalization not included here!

Preliminary results for ^{242}Pu below the fission threshold



- Spontaneous fission rate is similar to the (n,f) rate in these measurements. However, this is easy to correct for.
- The fission contribution from ^{241}Pu has still to be corrected for.
- WNR data is needed to extend the measurement above fission threshold.

Preliminary data for ^{240}Pu below the fission threshold



- Preliminary data indicate that the detector and data acquisition can handle this very active sample
- Analysis is underway
- WNR data is needed to extend the measurement above the fission threshold.

Conclusions

- The $^{237}Np(n,f)$ cross section measurement was successfully completed from 0.01 eV to 200 MeV
- Systematic errors are below 2% in the energy range of interest to AFCI
- Preliminary results for Pu-242 and Pu-240 show that the same technique used for ^{237}Np can be applied to these more active samples